METHOD FOR APPLYING AN ELECTRICAL INSULATION

[0001] Prior Art

[0002] The invention is based on a method for applying an electrical insulation to a ferromagnetic body, provided with axial slots for receiving an electrical winding, of a primary element of an electrical machine, in particular to a slotted armature body of an armature of a direct-current motor, as generically defined by the preamble to claim 1.

[0003] A slotted armature body of an armature of a direct-current motor, of the kind shown for instance in plan view in Fig. 2, comprises a plurality of profiled laminations 11, which are lined up axially one after the other and joined to make a lamination packet. The armature body 10 is press-fitted onto an armature shaft 13. The armature body 10 has a plurality of axial slots 14, which are open to both face ends of the cylindrical armature body 10 and which discharge at a slot opening 141 in the cylindrical surface of the armature body 10. An armature winding in the form of coils is wound into the axial slots 14. The coils are wound from an insulated coil wire, such as painted copper wire. Before the armature winding is wound in place, the axial slots 14 and also the face ends of the armature body 10 are provided with an electrical insulation 15, which is shown in Fig. 1 for only one axial slot 14.

[0004] In the possible methods for applying such an insulation 15, coating the armature body 10 with electrostatically charged plastic powder has proven itself as the most economical method, with the additional advantage that the slot cross section is reduced

only insignificantly by the insulation 15, and a quite high slot fill factor for the armature winding can thus be achieved.

[0005] In a known method, shown as a flow chart in Fig. 1, for applying the electrical insulation 15 to the armature body 10 by means of electrostatic powder coating, the armature body 10 already pressed together with the armature shaft 13 is precleaned, to eliminate contamination occurring in manufacture; masked at both points that are not to be coated, such as the armature shaft 13; and coated in a powder fluid bath with electrostatically charged plastic powder. The masks additionally take on a clamping function for fixing the armature body on a conveyor system that passes through the fluid bath, and for this purpose the armature bodies have to be repositioned on the conveyor system after masking. The bottom of the fluid bath comprises a porous plate, through which ionized or in other words electrically charged compressed air flows, which electrostatically charges the powder uniformly and fluidizes the powder, so that the powder behaves like a fluid. The electrostatically charged powder particles, because of the charges that are opposite the force of attraction, settle on the armature bodies being guided through the fluid bath and remain stuck to them. The thus-coated armature bodies are cleaned outside the fluid bath in a further method step, to remove powder adhering to the cylindrical surface of the armature bodies. Next, the cleaned armature bodies are delivered to a heating section, in which by heat input, the powder layer is melted and fired and hardened. The armature bodies are repositioned again and unmasked in a further method step. The unmasked armature bodies are then cooled down in a chilling zone. The removed masks are delivered to a mask cleaner, and with the cleaned masks, new, precleaned armature bodies are masked. The cooled-down

armature bodies 10 are removed from the processing system and delivered to an automatic winder.

[0006] This method produces a thin insulation layer, approximately 50 to 100 μm thick, in the axial slots with good thermal and electrical properties, but has decisive disadvantages in terms of costs. For instance, the fluid bath requires a horizontal position of the armature bodies, which in the rest of the production process are usually processed vertically, so that as the method progresses, the armature bodies have to be repositioned multiple times. Moreover, a quite complicated conveyor system is required for feeding the armature bodies through the fluid bath. If damage occurs in the fluid bath, replacing the fluid bath that is integrated into the system is extremely time-consuming and leads to expensive system down times. The masks also take on the function of clamping the armature bodies while they are being conveyed. If the masks become worn, inadequate clamping of the armature bodies can occur, which threatens the course of the process and leads to down times.

[0007] Advantages of the Invention

[0008] The method of the invention having the characteristics of claim 1 has the advantage that it can be implemented much more economically than the known method and assures effective powder coating with reliable slot insulation. The components required for performing the method are standard components conventionally available on the market, of the kind used for instance in painting automobiles or in other painting systems for decorative surfaces and are available worldwide. These standard

components require only little investment expense and are easy to maintain, so that functional parts can be quickly replaced and down times for maintenance and repair are reduced to a minimum. In the event of malfunctions or an inadequate throughput of material, the powder stream can immediately shut down, and thus the use of powder can be optimized.

[0009] The method of the invention thus takes on all the advantages of electrostatic powder spray-coating for decorative surfaces and, unlike that method, also assures reliably insulated coating of the slot walls with plastic powder. The application of a high layer thickness assures that a sufficiently thick powder layer will become deposited on the slot walls; this layer is as a rule thinner than the powder layer on the cylindrical surface of the body, yet it offers reliable insulating lining of the slots. The high layer thickness applied is greater by a factor 10 to 50 than the layer thicknesses that are achieved in powder coating of decorative surfaces and is in the range of approximately 1 to 1.5 mm. In electrostatic powder spraying, the axial slots are so-called Faraday cages, which are field-free, since the field lines of the magnetic field that develops between the spray source and the preferably grounded body, along which lines the electrically charged powder particles move, are concentrated at tips and protrusions and do not penetrate into the axial slots. Because of the so-called electrostatic embrace, that is, the fact that the field lines also extend to the face ends of the armature body, powder particles, while being electrostatically deposited at the ends of the slots, are not deposited in the slot interior. By the application of what according to the invention is a high layer thickness, the deposition of powder does occur first at points with high field line concentration at the beginning of the coating process. However, as spraying

continues, saturation at these points ensues. The saturated points can no longer be coated, since a charge concentration occurs there. The powder particles that continue to arrive carry the same charge and are spun away from the body by electrostatic repulsion (back-spray effect). Since the spray source is electrically identically charged, however, the particles are not speeded up backward but instead are no longer subject to any external force from the field lines and penetrate into the interior of the axial slots.

[0010] Another advantage of the method of the invention is the improvement in handling the bodies in the production process, since unlike the known method that uses a fluid bath, the bodies can be sprayed in an arbitrary position and need not necessarily be put into a horizontal position. This dispenses with repositioning of the bodies, and thus further auxiliary stations in the course of the method can be dispensed with.

[0011] By the provision recited in the further claims 2 through 9, advantageous refinements of and improvements to the method defined by claim 1 are possible. A preferred apparatus for performing the method is defined by claims 10 and 11.

[0012] Drawing

[0013] The invention is described in further detail below in terms of an exemplary embodiment shown in the drawing. Shown are:

[0014] Fig. 1, a flow chart of a method for applying an insulation to armature bodies for electrical machines in the prior art;

[0015] Fig. 2, a cross section through an armature body pressed onto an armature shaft;

[0016] Fig. 3, a flow chart of the method of the invention for coating armature bodies with insulation;

[0017] Fig. 4, a schematic illustration of a conveyor system for the passage of armature bodies through the coating process;

[0018] Fig. 5, a block circuit diagram of a system for electrostatic powder spray-coating;

[0019] Fig. 6, a schematic illustration of a powder coating chamber with an integrated powder supply.

[0020] Description of the Exemplary Embodiment

[0021] The method for applying an electrical insulation to a ferromagnetic body, provided with axial slots for receiving an electrical winding, of a primary element or in other words a stator or a rotor of an electrical machine will be described in terms of a slotted armature body 10 of an armature of a direct-current motor. The armature body 10, which can be seen end-on in Fig. 2, comprises a plurality of profiled laminations 11, which are lined up one after the other to form a so-called lamination packet and are axially joined firmly together. Instead of a profiled lamination packet, the armature body 10 may be embodied as a solid cylinder of soft magnetic composite material, or

SMC (Soft Magnetic Composite) material. The armature body 10 is provided in a known manner with a plurality of axial slots 14, located equidistantly over the circumference of the body, for receiving an armature winding.

[0022] The armature bodies 10, pressed onto the armature shaft 13, are precleaned in a first method step, "precleaning", 21 (Fig. 3), in order to eliminate such manufacturing residues as trimmings from stamping and coolant residues. The precleaned armature bodies 10 are placed on a conveyor belt 22 with clamping devices 23 (Fig. 4) that fix the armature shaft 13 and are carried by the conveyor belt 22 through three method steps, "coating" 24, "cleaning" 25, and "firing" 26. In the "coating" method step 24, the armature bodies 10 are coated with electrostatically charged plastic powder. The coating is done with a layer thickness of approximately 1 to 2 mm, preferably approximately 1.0 to 1.5 mm - which includes production-dictated deviations - by direct powder spraying onto the preferably grounded armature body 10. It suffices if the armature body 10 has a lower electrical potential than the plastic powder; this is most simply attained, naturally, by grounding. However, it is also possible for the armature body 10 to have a higher potential. What is essential is that the armature body 10 have a potential difference, compared to the electrostatically charged plastic powder, such that the plastic powder reaches the armature body 10.

[0023] In the "cleaning" method step 25, the cylindrical surface of the coated armature bodies 10 is freed of the powder layer adhering to it, and in the "firing" method step 26, the coated armature bodies 10 are exposed to a heat input, as a result of which the powder layer applied to each armature body 10 melts and hardens. The layer thickness

drops in this process to approximately one-third of the powder layer originally sprayed on. After that, the armature bodies 10 are removed from the conveyor belt 22 by means of a repositioning tool 27 (Fig. 4) and are cooled down in the "cooling" method step 28. Finally, the armature bodies 10, provided with the insulation, are removed from the method cycle in the "armature removal" method step 29 and delivered for instance to an automatic winder. In the return segment of the conveyor belt 22, the clamping devices 23 of the conveyor belt 22 are cleaned of powder residues by means of cleaning brushes 30.

[0024] In Fig. 5, the components required for performing the "coating" method step 24 are shown in a block circuit diagram. The spraying of the electrostatically charged plastic powder onto the grounded armature bodies 10 is done in a closed spraying chamber 31, through which the conveyor belt 22 passes with its upper, delivery section. The flow of parts, that is, the passage of the armature bodies 10 through the chamber 31, is represented by the arrow 20. The grounding of the armature bodies 10 is effected via the conveyor belt 22, which has clamping devices 23 and is in turn grounded. A spray apparatus 32 is integrated with the chamber 31 and via at least one spray location 33, by means of compressed air, sprays a metered quantity of powder onto each armature body 10. To that end, a so-called spray gun or corona gun is disposed at each spray location 33, and its spraying direction is aimed at the particular armature body 10 moving past it. Such spray guns are available on the market as standard components and are used for instance in painting decorative surfaces. The spray guns are connected to a voltage potential of approximately 70 kV for the sake of electrically charging the powder particles. The quantity of powder sprayed per armature body 10 is metered

such that a layer thickness of preferably 1.0 to 1.5 mm is created on the armature body 10. A coarse plastic powder is used, whose powder particles have a mean diameter of more than 150 μm. These heavy powder particles improve the overcoming of the Faraday effect mentioned at the outset and lead to an improved, uniform coating of the slot walls of the axial slots 14 in the armature body 10. Powder that does not reach the armature bodies 10 is delivered, via a so-called "overspray" line 34, to a powder bin 36, in which the compressed air laden with powder particles is passed through filters and flows out into the environment as waste air (arrow 37). The powder particles trapped by the filters drop back into a powder supply stored in the powder bin 36.

[0025] The quantity of powder delivered to the spray guns is made available by a metering device 35, which in turn is supplied with powder from the powder bin 36 by means of a pneumatic powder conveyor 38. The powder conveyor 38 is connected to the powder bin 36 via a suction line 40 that is controllable by a valve 41, and in the suction line 40 it generates an underpressure, by which when the valve 41 is open powder is aspirated from the powder bin 36; this powder is delivered with compressed air to the metering device 35.

[0026] Fig. 6 schematically shows the combination of the spraying chamber 31 with the powder bin 36 in a common housing 42, as a compact integrated version of a coating chamber. The powder-laden air stream originating at the spray locations 33 or spray guns is carried, after flowing past the armature bodies 10, directly into the powder bin 36, in which the air can pass via filters 39 as waste air (arrow 37) into the environment. The powder residues deposited in the filter 39 drop onto the powder

supply stored in an indented bottom of the powder bin 36. From there, powder is aspirated by the pneumatic powder conveyor 38 and returned to the spray locations 33 via the metering device 35. For the sake of simplicity, in Fig. 4 only two spray locations 33 and in Fig. 5 only one spray location 33 are shown. The number of spray locations 33 in the spray apparatus 32, however, is arbitrary and is adapted to the desired throughput speed of the armature bodies 10 through the chamber 31.